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Contents

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A SYSTEMATIC STUDY OF THE MAIN ARTERIES IN THE REGION OF THE HEART—AVES VIII

ANSERIFORMES. PART I[1]

BY FRED H. GLENNY[2]

Abstract

Seventeen species of the order Anseriformes were dissected and diagrams of the arrangement-patterns of the main arteries of the neck and thorax prepared. All specimens were found to be bicarotidinae normales. Both the right ligamentum aortae and the left ligamentum botalli were present in all of the forms that were studied. Three new vessels were found in several species of ducks. The allantoic artery arises as a branch of the left ischiadic artery in the embryonic Canada goose. The left radix aortae forms an anastomosis with the left pulmonary arch after atrophy of the left systemic arch. The left ductus botalli atrophies after this anastomosis and disappears almost entirely by the time the bird hatches.

Introduction

In recent studies (4–12) on the main cervical and thoracic arteries of birds, the writer has discussed the variation in arrangement-patterns of these arteries in several families of birds, particularly with reference to intraordinal variations. In most of the orders thus far considered, the specific deviation from the family or order arrangement or both is but slight. Among the members of the Anatidae (Order Anseriformes), however, specific as well as individual variation appears to be the rule, and there does not seem to be any particularly outstanding characteristic arrangement-pattern for the various genera at the present stage of these studies.

Such variations as were repeatedly observed were largely dependent upon the position of the origin of the vertebral, intercostal, axillary, and coracoid major arteries, the origin and number of superficial cervical arteries, and presence or absence of the basifurcula, secondary coracoid minor, and pericardial arteries. Further consideration of these vessels will be given, for each of the species studied, in the observations.

Garrod (3) points out that in the order (Anseres) Anseriformes both carotids are present and enter the hypapophysial canal*. He points out further that

[1] *Manuscript received October 19, 1943.*

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**Garrod (3) lists the following species in his studies on the carotid arteries: Anser segetum, Chloëphaga sp., Cygnus nigricollis, Cygnus buccinator, Bernicla canadensis, Cygnus coscoroba, Dendrocygna autumnalis, Dendrocygna viduata, Dendrocygna fulva, Tadorna rutila, Aix galericulata, Mareca penelope, Dafila spinicauda, Querquedula crecca, Metopiana peposaca, Fuligula cristata, Mergus castor, and Mergus albellus.*

the arrangement of the carotids (except in the Psittaciformes) may be significant in classification, and that the uniformity of the carotid arrangement is of gross ordinal importance (3, p. 471).

Garrod also noted, as has the present writer (11), that in somewhat ill-defined groups—particularly the Coccyges—the carotids give rise to characters that may be of family value. Although the Coccyges have been further divided by later taxonomists, there are still several points of difference within the Coraciiformes that seem to indicate that this order is still incompletely defined, and that further subdivision or reallocation of families might be in order (11).

Lowe (16), on the other hand, appears to favour regrouping the present families and orders of birds into larger (more generalized) orders in an effort to show the more fundamental relationships of present-day birds, with reference to their probable ancestral origins and relationships. The present writer is in agreement with Lowe in this view, if such rearrangement of existing orders of birds is based upon sufficient evidence. Such evidence must be based upon:

(*a*) Total embryological evidence concerning development and growth of all important organ systems.

- (i) Relative development and growth of all important parts of the skeletal system.
- (ii) Development, origin and insertion, and relative size of muscles (particularly the syrinx, tracheal, cranial, and appendicular muscles), with a reference to their functional modifications.
- (iii) Development of the aortic arches and other main blood vessels (including the omphalomesenteric and nephric arteries).
- (iv) Incubation periods and temperatures.
- (v) Period of posthatching parental feeding and care.
- (vi) Feather development (types formed, etc.).
- (vii) Development and growth of the alimentary tract.

(*b*) Total gross and fine anatomical evidence with reference to the ultimate fate of the embryonic structures—also with regard to their occurrence in orders of birds derived from different reptilo-avian ancestors, which are, therefore, not closely related, but which illustrate the incidence of parallel development in different and widely separated groups of birds.

(*c*) Fossil evidence as a basis for the establishment of relationships, to be correlated with both embryological and anatomical findings.

(*d*) Important factors of physiology (such as the oxygen and carbon dioxide concentration of the blood) that may be correlated with these same physiological factors in the different groups of extant reptiles.

Finn (1) demonstrated the presence of a patent ductus caroticus (misnamed ductus botalli) in *Dafila spinicauda* (Fig. 1). At the same time he pointed

out that the occurrence of such a structure was an individual variation and not a specific character. In 1939, Bhaduri illustrated (Fig. 2) the presence of a patent ductus caroticus in the blue rock pigeon of India (*Columba livia intermedia* Strich). Glenny likewise has pointed out that patent ducti or partially occluded ducti may occur in some of the Columbidae (4) and Picidae (10). He has shown, however, that there may be a tendency in a group of birds to retain certain of these embryonic vessels at least as ligamentous vestiges (4, 12) and that retention of these vestiges may be considered as a general character for different groups of birds.

It should be noted that, whereas Garrod (3) placed the Coscoroba duck among the swans (*Cygnus*), this species now occupies a place in a separate genus (*Coscoroba*) and is placed among the true ducks.

Materials

Seventeen species of birds (listed below), of the order Anseriformes, were included in this study. The materials that were used for study were provided by the Royal Ontario Museum of Zoology, Toronto, Ont., Canada, and by Meems Bros. and Ward, Inc., of Oceanside, Long Island, N.Y.

Unless otherwise indicated below, only single specimens were dissected; diagrams of the main arteries in the neck and thorax were prepared for study and analysis.

Cygnus olor (Gmelin)—European mute swan
Branta canadensis leucopareia (Brandt)—Lesser Canada goose
Alpochen aegyptiaca (Linné)—Egyptian goose
Chen atlantica Kennard—Snow goose
Chen caerulescens (Linné)—Blue goose
Anser albifrons albifrons (Scopoli)—White-fronted goose
Coscoroba coscoroba (Molina)—Coscoroba duck
Oidemia nigra americana (Swainson)—American scoter
Melanitta fusca deglandi (Bonaparte)—White-winged scoter (three specimens)
Melanitta (subgenus *Pelionette* Kaup) *perspicillata* (Linné)—Surf scoter (two specimens)
Nyroca marila (Linné)—Great scaup duck
Nyroca collaris (Donovan)—Ring-necked duck (two specimens)
Clangula hyemalis (Linné)—Old squaw duck (two specimens)
Bucephala clangula americana (Bonaparte)—American golden eye
Bucephala albeola (Linné)—Buffle-head duck
Mergus serrator Linné—Red-breasted merganser (three specimens)
Mergus merganser americanus Cassin—American merganser

Observations

The basic ordinal arrangement-pattern of the arteries in the Anseriformes is characteristic for the group. The aortic root (*1*) arises in the left ventricle of the heart, passes diagonally toward the right and anteriorly, and finally

bifurcates to form the left and right innominate arteries (*2*). The right fourth aortic arch (*3*) arises at or near the base of the right innominate and makes a dorsolateral loop or arch to join the descending aorta (*4*) (right radix aortae) which in turn passes posteriorly and diagonally toward the centre of the body just dorsal to the heart where it joins the dorsal aorta (*5*) and the ligamentum aortae (*6*) (of the adult), just anterior to the gastromesenteric artery. The right ligamentum botalli (*7*) is present.

Anteriorly the innominate arteries divide to form the subclavian (*9*) and common carotid (*10*) arteries. The subclavians give rise to the coracoid major (*11*), axillary (*12*), intercostal (*13*), and two pectoral (*14*) arteries in order. The common carotids (*10*) are joined variously by the ductus shawi (*16*), thyroid (*29*), superficial cervical (*24* and *25*), vertebral (*21*), oesophageal (*24b* and *27*), and internal carotid (trunk) (*23*) arteries.

The sternotracheal (*15*) and coracoid minor (*28*) arteries vary in their origins as do the ascending oesophageal arteries in each of the several species. The ductus shawi (*16*) sends off branches that supply the meso- (*19*) and basioesophageal areas, the trachea and syrinx (*18*), bronchi, and connective tissues dorsal to the heart.

FIG. 1. *Diagram of the main arteries at the base of the neck of Nyctocorax violaceus. (After Finn). Ventral view.*

FIG. 2. *Diagram of the main arteries of the neck and thorax of Columba livia intermedia. (After Bhaduri). Ventral view.*

FIG. 3. *Diagrammatic representation of the arteries in the Canada goose, Branta canadensis leucopareia, at the time of hatching. Ventral view.*

KEY (Figs. 1, 2, and 4 to 18)

(*1*) Aortic root; (*2*) innominate artery; (*3*) systemic arch; (*4*) right radix aortae; (*5*) dorsal aorta; (*6*) ligamentum aortae; (*7*) right ligamentum botalli; (*8*) pulmonary arch; (*9*) subclavian artery; (*10*) common carotid artery; (*11*) coracoid major artery; (*12*) axillary artery; (*13*) intercostal artery; (*14*) pectoral arteries; (*15*) sternotracheal artery; (*16*) ductus shawi; (*17*) pericardial artery; (*18*) syrinx artery; (*19*) meso-oesophageal artery; (*20*) basifurcula artery; (*21*) vertebral artery; (*22*) scapular artery; (*23*) internal carotid (trunk) artery; (*24a*) primary ascending oesophageal artery; (*24b*) right lateral superficial cervical artery; (*25a*) left lateral superficial cervical artery; (*25b*) left ventral superficial cervical artery; (*26*) cervico-oesophageal artery; (*27*) accessory or secondary oesophageal artery; (*28*) coracoid minor artery; (*29*) thyroid artery; (*30*) ductus caroticus; (*31*) basicervical artery; (*32*) ascending tracheal artery; (*33*) secondary coracoid minor artery.

KEY (Fig. 3)

(*1*) Aortic root; (*2*) systemic arch; (*3*) innominate artery; (*4*) right radix aortae; (*5*) right ductus botalli; (*6*) left radix aortae; (*7*) left ductus botalli; (*8*) pulmonary arch; (*9*) pulmonary artery; (*10*) dorsal medial intercostal artery; (*11*) common carotid artery; (*12*) ductus shawi; (*13*) meso-oesophageal and syrinx arteries; (*14*) posterior portion of ductus shawi; (*15*) coracoid minor artery; (*16*) scapular artery; (*17*) vertebral artery; (*18*) superficial cervical artery (right superficial cervical serves as ascending oesophageal); (*19*) descending superficial cervical artery; (*20*) internal carotid (trunk) arteries; (*21*) cephalic portion, internal carotids; (*22*) region of internal and external carotid anastomosis; (*23*) occipital artery; (*24*) auditory branch of internal carotid; (*25*) internal carotid branch to brain; (*26*) maxillary artery; (*27*) coracoid major artery; (*28*) axillary artery; (*29*) intercostal artery; (*30*) pectoral arteries; (*31*) subclavian artery; (*32*) coeliacomesenteric artery; (*33*) superior mesenteric artery; (*34*) gastric branch of coeliac (cardiac); (*35*) pyloric branch of coeliac; (*36*) pancreatic artery; (*37*) renal or nephric arteries; (*38*) ischiadic artery; (*39*) iliac artery; (*40*) allantoic or umbilical artery; (*41*) posterior mesenteric artery; (*42*) caudal artery; (*t*) thyroid artery and gland; (*st*) sternotracheal artery.

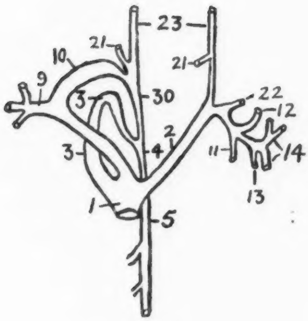


FIG. 1

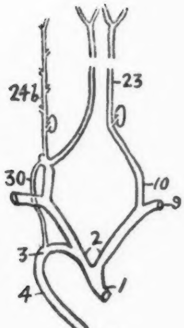


FIG. 2

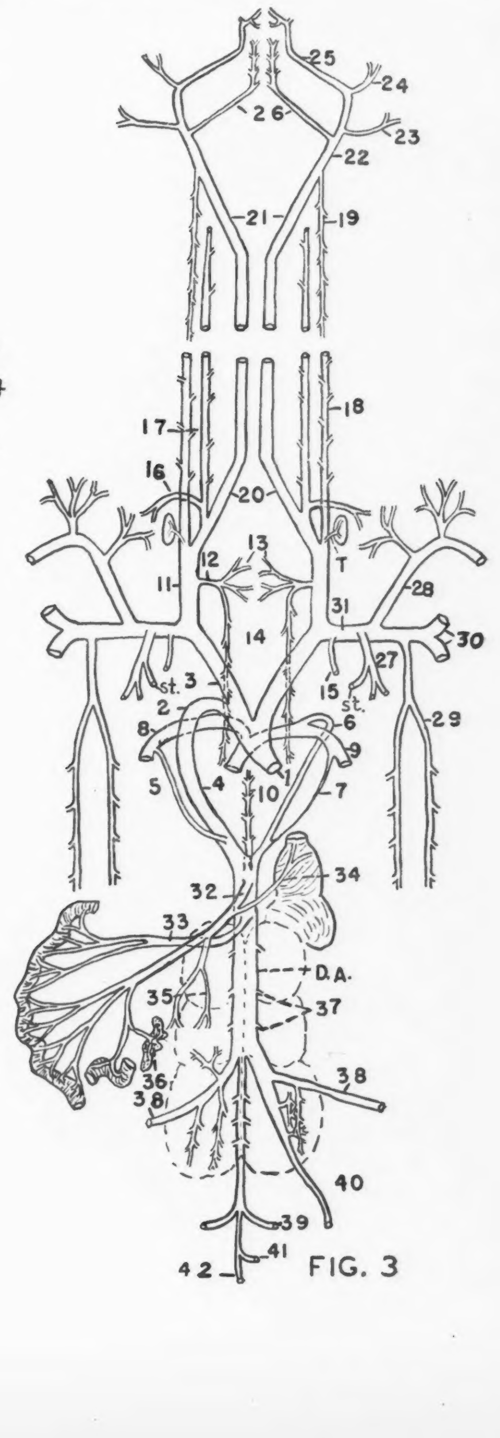


FIG. 3

Such individual and apparent specific differences as were observed are considered separately for each species studied.*

Branta canadensis leucopareia (Fig. 3)

The specimen of the Canada goose that was examined was one that had been collected from the nest just shortly after hatching. The arterial arrangement, therefore, is one that is found in a very late embryonic stage of the species. The diagram (Fig. 3) represents the arrangement-pattern of the main arteries not only in the neck and thorax, but in the head and abdomen (to a more limited extent) as well.

The aortic root (*1*) divides to form the two innominate arteries (*3*) which in turn divide to form the subclavian (*31*) and the common carotid (*11*) arteries. The systemic (fourth aortic) arch (*2*) arises at or near the base of the right innominate artery and continues posteriorly as the descending aorta or right radix aortae (*4*). The left radix aortae (*6*) anastomoses with the pulmonary arch (*8*) after the left systemic arch has atrophied (*11*). Both left and right radices aortae join to form the dorsal aorta (*DA*) near the apex of the heart.

The right ductus botalli (*5*) connects the right pulmonary arch and the right radix aortae. The left ductus botalli (*7*) becomes partially occluded and begins to atrophy distally. Complete atrophy with subsequent total obliteration of the left ligamentum botalli may follow during the early juvenile period. The dorsal medial intercostal artery (*10*) arises from the dorsal face of the dorsal aorta and passes anteriorly, along the ventral face of the thoracic vertebrae, for a short distance.

The subclavian artery gives rise to the coracoid minor (*15*), coracoid major (*27*), axillary (*28*), intercostal (*29*), and two pectoral (*30*) arteries in order. The coracoid major sends off the sternotracheal artery (*st*) before further branching. The intercostal divides into ventral and lateral branches.

The axillary artery sends several smaller vessels to supply the tissues at the base of the neck and shoulder before proceeding to the wing. The common carotids give off the ductus shawi (*12*) (functionally modified ductus caroticus), thyroid (*t*), ascending superficial cervical (*18*), vertebral (*17*), and internal carotid (trunk) (*20*) arteries. The scapular artery (*16*) arises near the base of the vertebral artery (*17*). The descending superficial cervical artery (*19*) arises from the anterior or cephalic end of the internal carotid artery (*21*) just before it divides to give rise to the branches of the external carotid artery—maxillary (*26*) and occipital (*23*) branches—and the branches of the internal carotid artery—auditory (*24*) and brain (*25*).

Posteriorly in the dorsal aorta gives rise to the following branches in order: coeliacomesenteric (gastromesenteric) (*32*), superior mesenteric (*33*), renal (nephric) (*37*), umbilical (allantoic) (*40*), ischiadic (*38*), posterior renals, iliac (*39*), posterior mesenteric (*41*), and caudal (*42*) arteries.

* *See Figs. 4 to 18 with key to figures. The numbers after the names of the vessels refer to corresponding numbers in the figures.*

The ischiadic arteries arise from the dorsal aorta as paired vessels. The left (functional) allantoic or umbilical artery arises near the point of origin of the left ischiadic artery as in the chick.

Cygnus olor (Fig. 4)

The subclavian gives rise to the coracoid major (*11*), axillary (*12*), intercostal (*13*), and two pectoral (*14*) arteries. The coracoid minor (*28*) arises as a branch of the axillary, while the sternotracheal (*15*) arises as the first branch of the intercostal.

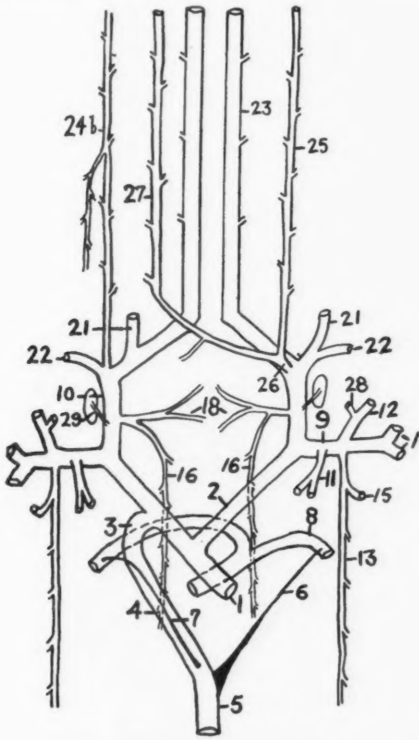


FIG. 4. *Diagrammatic representation of the arteries in the neck and thorax of the European mute swan, Cygnus olor. Ventral view.*

The common carotids give rise to the ductus shawi, which sends branches to the syrinx, trachea, bronchi, and oesophagus, and the thyroid artery before sending off the superficial cervical, vertebral, and internal carotid (trunk) arteries. The right scapular (*22*) arises separately from the common carotid. It may, however, have a common origin with the lateral superficial cervical artery or, as is more likely, with the vertebral artery, from the common carotid.

The right cervical artery sends off branches to the oesophagus, cervical lymph glands and musculature, and the skin of the neck. The right vertebral artery (*21*) arises alone from the common carotid—at least in the one specimen that was used in this study, although it may occasionally have a common root with the scapular artery as in *Alpochen aegyptiaca*.

The left common carotid gives rise to the cervico-oesophageal (*26*) which divides to form the primary ascending oesophageal artery (*27*) and the left superficial cervical artery (*25b*), before sending off the vertebral artery (*21*), from which the scapular artery (*22*) arises, and the internal carotid (trunk) artery (*23*). Both left and right internal carotid arteries enter the hypapophysial canal and pass anteriorly to the head, sending off small segmental arteries along their course.

The left ligamentum aortae (*6*) and the right ligamentum botalli (*7*) are both present as prominent vestiges that maintain their proximal attachments to the pulmonary arteries (*8*).

Alpochen aegyptiaca (Fig. 5)

The coracoid major gives rise to the arteria basifurcula (*20*) before further dividing. The sternotracheal artery (*15*) arises as a branch of the intercostal artery (*13*). The arteria pericardia (nova arteria) (*17*) is a paired vessel that arises from the subclavian artery (*9*) near the base of the coracoid major (*11*) and supplies the pericardium—ventrally and laterally. It appears to supply

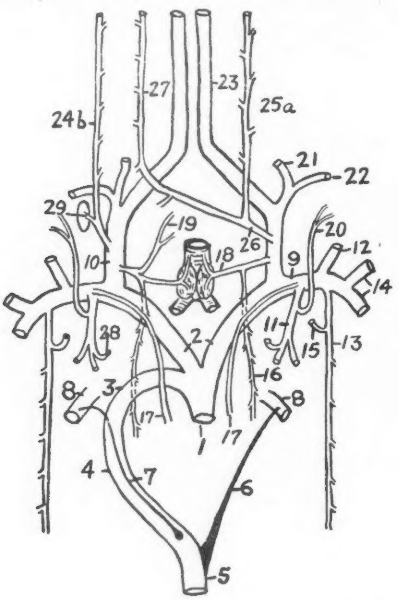


FIG. 5. *Diagram of the arteries in the neck and thorax of Alpochen aegyptiaca. Ventral view.*

no other tissues. The coracoid minor (*28*) is a branch of the coracoid major. The right ductus shawi (*16*) receives a short meso-oesophageal artery (*19*). The right superficial cervical artery (*24b*) arises from the common carotid (*10*), while the left superficial cervical (*25b*) arises from the cervico-oesophageal artery (*26*) from which vessel the primary ascending oesophageal artery (*27*) is also derived. The cervico-oesophageal artery arises from the left common carotid. Both left and right scapular arteries (*22*) arise as branches of the vertebral arteries (*21*).

Chen caerulescens (Fig. 6) *and Anser albifrons albifrons*

Both the blue goose and the white-fronted goose have about the same pattern of arteries in the region of the neck and thorax. The sternotracheal (*15*) arises as a branch of the coracoid major (*11*), while the coracoid minor (*28*) arises as a branch of the axillary (*12*) artery. The accessory oesophageal (*27*) arises as a branch of the left ductus shawi (*16*). Both left and right superficial cervical arteries arise separately from the common carotids, and not from the vertebral arteries (*21*) as in some other species. The right superficial cervical (*24a*) serves as the primary ascending oesophageal artery. The scapular arteries (*22*) are branches of the vertebral arteries (*21*).

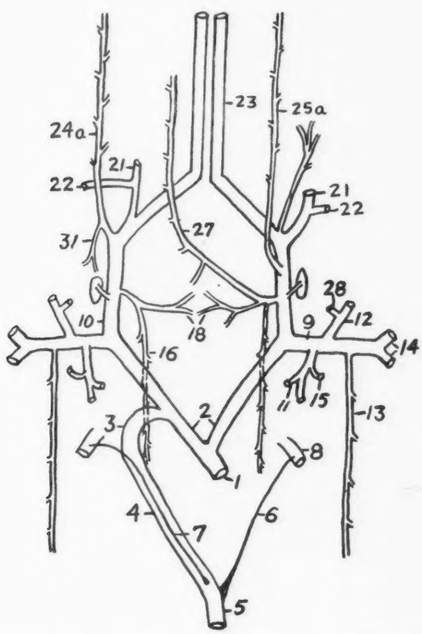


FIG. 6. *Diagrammatic representation of the arteries in the neck and thorax of Chen caerulescens. Ventral view.*

Chen atlantica

The arrangement-pattern of the arteries of the snow goose is similar to that found in *Chen caerulescens* (Fig. 6) and *Anser albifrons albifrons* except that the sternotracheal artery (*15*) is derived from the intercostal artery (*13*), and the secondary oesophageal artery arises from the common carotid artery instead of from the left ductus shawi.

Coscoroba coscoroba (Fig. 7)

The Coscoroba duck is similar to *Oidemia nigra americana* (below) in arterial arrangement. The scapular arteries (*22*), however, appear to be lacking so that the blood supply to the shoulder area is furnished by the arteria basifurcula (*20*) (at least in part) which, along with the sternotracheal artery (*15*), is derived as a branch of the coracoid major artery (*11*). The tracheal blood supply is increased by a large number of branches from the tracheal arteries (*32*) that arise as branches from the ductus shawi (*16*) and are bilaterally uniform. The coracoid minor (*28*) is a branch of the axillary artery (*12*).

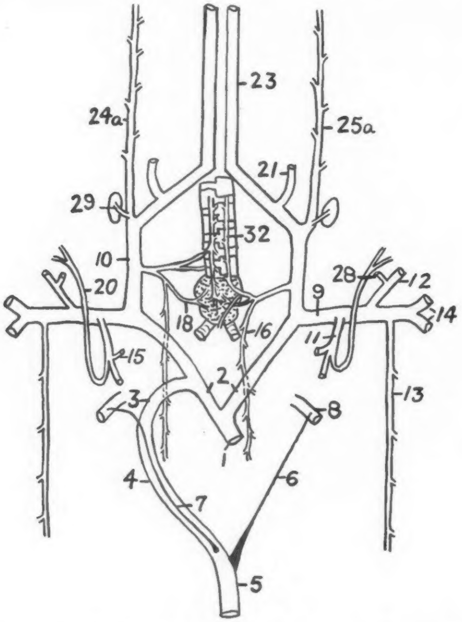
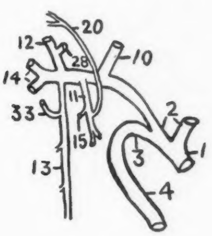


FIG. 7. *Diagram of the arteries in the neck and thorax of Coscoroba coscoroba. Ventral view.*

Oidemia nigra americana (Fig. 8)

The coracoid major artery (*11*) gives rise to the sternotracheal artery (*15*) and the arteria basifurcula (*20*) before further dividing to supply the muscles

on the dorsal surface of the coracoid bone. The coracoid minor secunda (*33*) arises as the first branch of the intercostal artery (*13*). As in *Clangula hyemalis* (Fig. 14), the left ductus shawi sends off a small ascending oesophageal artery (*27*), which does not divide further to form a ventral superficial cervical artery as it (the left ductus shawi) does in *Alpochen aegyptiaca* (Fig. 5). The common carotids are bilaterally symmetrical and give off the superficial cervical (*24* and *25*), vertebral (*21*), and internal carotid (trunk) (*23*) arteries in order. The superficial cervicals give rise to a short thyroid artery (*29*) and a scapular artery (*22*) before sending off branches along the neck. The right superficial cervical (*24a*) also serves as a primary ascending oesophageal artery.



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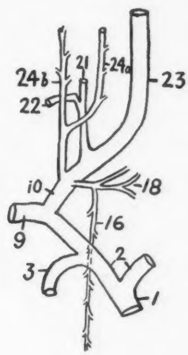

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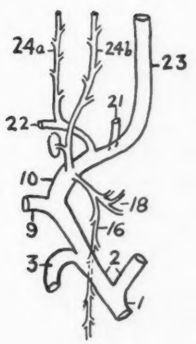

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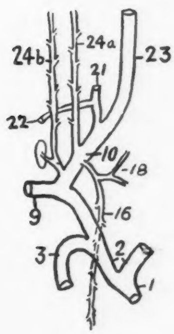

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FIG. 8. *Diagram of the arteries at the base of the neck and in the shoulder region of Oidemia nigra americana, right side only. Ventral view.*

FIGS. 9, 10, 11. *Diagrammatic representations of the arteries at the base of the neck, right side only, of Melanitta fusca deglandi. Ventral view.*

Melanitta fusca deglandi (Figs. 9, 10, 11)

In the three specimens examined, the cervico-oesophageal artery (*26*), the vertebral (*21*), lateral superficial cervical (*25*), and scapular (*22*) arteries arise from the left common carotid (*10*) artery as in *Nyroca marila* (Fig. 12), but the primary ascending oesophageal (*24a*), vertebral (*21*), lateral superficial cervical (*24b*), and scapular (*22*) arteries on the right side vary greatly in their origin and arrangement.

In the first (Fig. 9), the oesophageal (*24a*) and superficial cervical (*24b*) arteries have a common origin (*24*), while the scapular (*22*) arises from the vertebral artery (*21*) near its base on the common carotid (*10*). In the second (Fig. 10), the oesophageal artery from the left side (*27*) serves as the primary ascending oesophageal artery, while the accessory oesophageal (*24b*) is a smaller vessel that arises from the right common carotid artery. The lateral superficial cervical (*24a*) gives off the scapular (*22*), and the left vertebral artery arises separately from the carotid artery. In the third specimen (Fig. 11), the arrangement is more nearly like that in the first specimen except that the lateral superficial cervical (*24b*) and the ascending oesophageal (*24a*) arteries arise separately from the common carotid artery and the scapular artery arises as a branch of the vertebral artery.

Melanitta perspicillata

The surf scoter is like *Oidemia nigra americana* (Fig. 8) except that the sternotracheal artery (*15*) arises as a branch of the intercostal artery (*13*); the basifurcula (*20*) and secondary coracoid minor (*33*) arteries could not be observed; and the primary ascending oesophageal and left lateral superficial cervical arteries have a common origin in a cervico-oesophageal artery (*26*), which arises from the left common carotid artery, as shown in Fig. 5. The scapular arteries arise as branches of the lateral superficial cervical arteries (*24b* and *25a*). The right superficial cervical serves as an accessory oesophageal artery. The right ligamentum botalli (*7*) is very small although it still tends to maintain its earlier connection with the right pulmonary artery (*8*).

Nyroca marila (Fig. 12)

The sternotracheal artery (*15*) is a branch of the intercostal (*13*), while the coracoid minor (*28*) arises from the axillary artery (*12*). The right common carotid gives rise to a small lateral superficial cervical artery (*24b*) from the base of which arises the right thyroid artery (*29*). The common carotid then gives rise to the vertebral (*21*) and internal carotid (trunk) (*23*) arteries. The vertebral artery sends off the primary ascending oesophageal (*24a*) and scapular (*22*) arteries near its origin before passing dorsally and anteriorly along the neck. The left and right internal carotids enter the hypapophysial canal and pass anteriorly to the head without fusing. The left common carotid artery gives rise to a short thyroid artery, the ductus shawi (*16*), and then a cervico-oesophageal (*26*) artery, which divides to form a ventral superficial cervical (*25b*) and an accessory oesophageal artery (*27*). The common carotid then divides to form the left internal carotid (trunk) (*23*) and the left

vertebral artery (*21*) which sends off the left lateral superficial cervical (*25a*) and scapular (*22*) arteries before passing anteriorly.

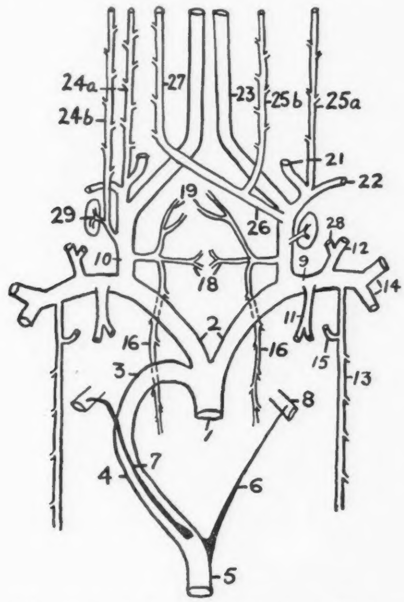


FIG. 12. *Diagram of the arteries in the neck and thorax of Nyroca marila. Ventral view.*

Nyroca collaris (Fig. 13)

The arrangement of the secondary branches from the carotid arteries, in the ring-necked duck, is the same as that of the one specimen of *Melanitta fusca deglandi* (Fig. 11). The sternotracheal artery (*15*) arises as the first branch from the intercostal artery (*13*).

Clangula hyemalis (Fig. 14)

The accessory oesophageal artery (*27*) arises from the left ductus shawi (*16*) and does not further divide to give rise to a left ventral superficial cervical artery, but proceeds anteriorly along the left face of the oesophagus. The scapular (*22*), left lateral superficial cervical (*25a*), and the left vertebral (*21*) arteries have a common origin at the point where the common carotid (*10*) gives rise to the vertebral and internal carotid (trunk) arteries as in *Mergus* and other genera. The complementary vessels on the right side are similarly arranged and, in the specimens that were studied, presented a short basicervical artery (*31*). The meso-oesophageal arteries from the right ductus shawi are lacking or extremely small in this species, but the oesophageal blood supply is derived from the left oesophageal artery. The right lateral superficial arteries (*24a* and *24b*) arise as in other species of the Anatidae. The larger, more ventral vessel (*24a*) serves as an ascending oesophageal artery,

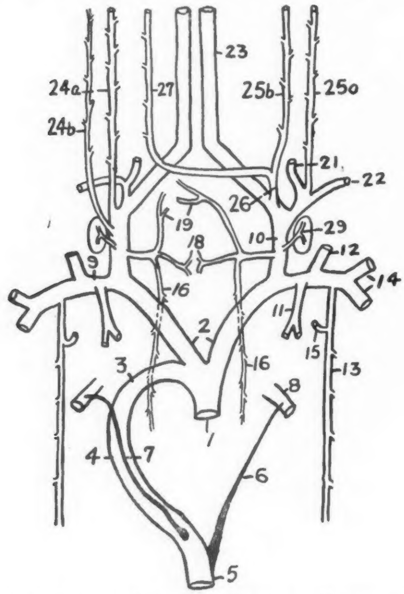


FIG. 13. *Diagram of the arteries in the neck and thorax of Nyroca collaris. Ventral view.*

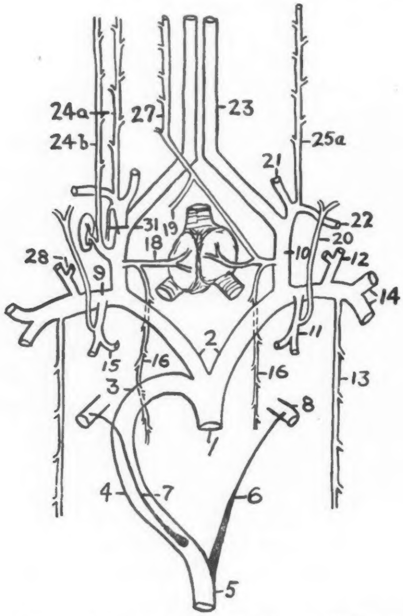


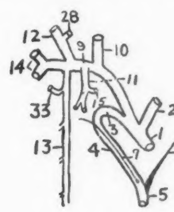
FIG. 14. *Diagram of the arteries in the neck and thorax of Clangula hyemalis. Ventral view.*

while the other, more lateral vessel (*24b*) serves to supply the cervical lymph glands and the cervical musculature.

The sternotracheal artery (*15*) arises from the coracoid major (*11*), which also gives rise to the arteria basifurcula (nova arteria) (*20*). This vessel supplies the tissues at the base of the furcula near its articulation with the humerus and scapula. Both the ligamentum aortae (*6*) and the right ligamentum botalli (*7*) are much reduced in size.

Bucephala clangula americana (Fig. 15)

The arterial system in the neck and shoulder region of this species is similar to that of *Clangula hyemalis* except that the arteria basifurcula is lacking, and the arteria coracoid minor secunda (*33*) arises as the first branch of the intercostal artery (*13*). The right basicervical artery was not observed, although



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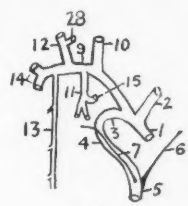

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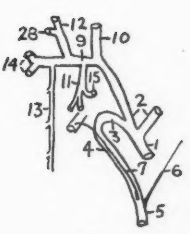

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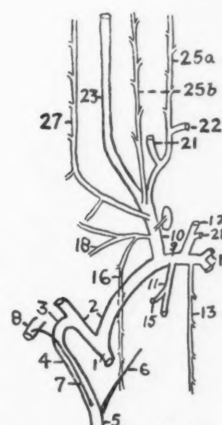

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FIG. 15. *Diagram of the arteries at the base of the neck and in the shoulder region of Bucephala clangula americana (right side only). Ventral view.*

FIG. 16. *Diagram of the arteries at the base of the neck and in the shoulder region of Bucephala albeola (right side only). Ventral view.*

FIG. 17. *Diagram of the arteries at the base of the neck and in the shoulder region of Mergus serrator (right side only). Ventral view.*

FIG. 18. *Diagram of the arteries in the neck and thorax (left side only) of Mergus merganser americana. Ventral view.*

it may be small and obscure. The right ligamentum botalli (*7*) is greatly reduced and fuses or tends to fuse with the radix aortae (*4*).

Bucephala albeola (Fig. 16)

The arterial system of the neck and shoulder region of the buffle-head duck is like that of *Bucephala clangula americana* (Fig. 15) except that it appears to lack the coracoid minor secunda artery, and, further, presents a slightly more prominent right ligamentum botalli (7).

Mergus serrator (Fig. 17)

Except for the origin of the sternotracheal artery (*15*) from the coracoid major (*11*), and the coracoid minor (*28*) from the axillary artery (*12*), the arrangement-pattern of the arteries of the red-breasted merganser in the neck and thorax was found to be the same as that of *Nyroca marila* (Fig. 12).

Mergus merganser americanus (Fig. 18)

Except for the fact that, in the specimen of the American merganser that was studied, the accessory oesophageal artery (*27*) and the left ventral superficial cervical artery (*25b*) joined the common carotid artery separately, the pattern is the same as that of *Mergus serrator* (Fig. 17) (in other specimens these two arteries may have a common origin from the common carotid artery) and presents an arrangement similar to that found in *Nyroca marila* (Fig. 12).

Discussion

As has been noted above, among the Anseriformes that were studied, the right ligamentum botalli is present as a vestige of the embryonic ductus arteriosus, while the left ductus arteriosus becomes entirely obliterated as a result of atrophy and partial fusion with the left radix aortae. As has been shown, in several studies by the present writer, during the embryonic development of birds the left radix aortae anastomoses with the pulmonary (sixth aortic) arch to take over the function of the ductus botalli. Although this may not be found true of all orders of birds, at least those orders thus far studied appear to undergo these changes. Ultimately the left radix atrophies and remains as a ligamentous vestige (ligamentum aortae).

In general it may be pointed out that in the Anseriformes the ligamentum aortae (*6*) maintains an attachment to the pulmonary artery even after the bird has reached maturity. This tendency is found throughout the Class Aves, although in many of the more highly evolved orders there appears to be considerable reduction in this ligamentous vestige. This is particularly true among several families of the Passeriformes, while among other orders only some of the families show a general tendency toward reduction and complete atrophy of this structure.

With regard to retention and functional modification of the ductus caroticus, the Anseriformes follow the general avian pattern (10).

It should be noted that in adult birds, the common carotid artery is but a short vessel, which arises from the innominate artery and proceeds anteriorly

as far as the point of origin of the superficial cervical arteries (ascending oesophageal artery of the right side). However, embryologically the innominate artery has its origin in the anterior portion of the ventral radices aortae (common carotid portion). The third aortic arch is maintained as a very short portion of this vessel. Owing to changes in position, it is extremely difficult to designate the exact portions of the adult vessels that arise from the different parts of the early embryonic vessels.

Lillie (14) states, ". . . the first and second arches disappear . . . and the anterior prolongation of the dorsal aortae in front of the third arch constitutes the internal carotid; the ventral ends of the first and second arches form the external carotid. The third arch on each side persists as the proximal portion of the internal carotids; and the dorsal aorta ruptures on each side between the dorsal ends of the third and fourth arches. The fourth arch and the root of the dorsal aorta disappear on the left side, but remain on the right as the permanent arch of the aorta . . ." Although Lillie (14) definitely states that the left radix aortae disappears, the present writer has shown conclusively that this is not the case. Lillie further states, ". . . On the third and fourth days of incubation the first and second aortic arches disappear. The lower ends of these arches then appear as a branch from the base of the third arch on each side, extending into the mandible and forming the external carotid artery. The dorsal aorta in front of the third arch constitutes the beginning of the internal carotid . . ."

With regard to the internal and external carotids, Hertwig (13) says, "... Die Carotis externa entspringt in der Verlängerung des Truncus arteriosus aus dem Anfang des ersten Schlundbogengefässes und wendet sich zur Ober und Unterkiefergegend. Die Carotis interna entsteht weiter dorsalwärts dort, wo die Umbiegung in die Aortenwurzeln erfolgt, und leitet das Blut zum embryonalen Gehirn und dem sich entwickelnden Augapfel (Arteria Ophthalmica) . . ."

Several illustrations by Locy (*in* 14) serve as aids in obtaining a better concept of the changes in the symmetry of the aortic arches and their derivatives and the ultimate fate of these embryonic vessels particularly in the cervical and cephalic regions.

Although among the Anseriformes there is considerable variation in origin and distribution of the superficial cervical vessels, all of the specimens otherwise follow the general basic arrangement-pattern of the order. Variation is particularly noticeable in the secondary or accessory oesophageal artery, which arises variously from the left side and which passes diagonally to the right side to supply the left face of the oesophagus.

It should be of interest to note that the accessory oesophageal artery in both *Nyroca marila* (Fig. 12) and *Nyroca collaris* (Fig. 13) arises from the short cervico-oesophageal artery (*26*) and that a somewhat similar origin of this vessel is found in *Alpochen aegyptiaca* (Fig. 5) and the European mute

swan, *Cygnus olor* (Fig. 4). The basic arrangement-patterns of the latter two species are closely similar.

The accessory oesophageal artery in *Chen caerulescens, Chen atlantica, Anser albifrons albifrons, Mergus merganser americana, Mergus serrator, Clangula hyemalis, Bucephala clangula americana,* and *Bucephala albeola* arises either from the left ductus shawi or separately from the left common carotid artery and generally near the point of origin of the left ductus shawi.

A significant point with regard to the degree of variation in origin of the superficial cervical arteries is illustrated by three specimens of *Melanitta fusca deglandi* (Figs. 9, 10, and 11). The question remains, however, whether or not these variations in branching (origin from the common carotid) are of importance with regard to subspecies variation and whether or not these slightly significant differences are points in species evolution that may be of phyletic significance. On the other hand some workers will hold that these variations are a matter of individual differences and that they result from chance anastomoses and are not, therefore, following normal orderly patterns of development. It is hard for this worker to conceive of a completely disorderly development in any group of organisms. It is more probable that through these chance variations (sports) a more definite line of development, with different arrangement-patterns, will develop and that over a sufficiently long period of time these new patterns will become so constant as to be of value in the delineation of at least subspecies. Conversely it may be possible better to establish close specific and generic relationships by detailed anatomical and embryological studies of these closely related forms.

The most characteristic feature of the arterial arrangement in the neck and thorax in the Anseriformes is the presence of two internal carotid (trunk) arteries of equal diameter, which traverse the entire length of the neck. Birds in which this arrangement occurs are referred to as *aves bicarotidinae normales* by Garrod (3) and differ from those that he referred to as *aves laevocarotidinae* in which there exists the condition encountered in the Passeriformes (5), Piciformes (10), certain families of Coraciiformes (11), and also many of the paleognathous birds (6, 7, and 9).

Accepting a poly-reptilian origin for the birds, it is natural to assume that the Anseriformes arose from a different "stem" than the Passeriformes, Piciformes, and certain Coraciiformes. At the same time it is probable that they had a separate origin from the penguins (15), *Apteryx*, emus, and struthious forms (12).

Acknowledgments

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THE SPOTTED FEVER AND OTHER ALBERTAN TICKS[1]

By John H. Brown[2]

Abstract

The Rocky Mountain spotted fever tick, *Dermacentor andersoni* Stiles, is present in large numbers throughout the greater part of southern Alberta. Since 1938 a total of 58,534 drag ticks and 3851 host ticks have been collected. These ticks were taken in 412 separate collections made in 18 different districts. Two collections, one made at Manyberries and the other at Lethbridge, showed that the ticks in those areas were infected with *Dermacentroxenus rickettsi* Wolbach, the causative organism of Rocky Mountain spotted fever. Sixteen collections made in various districts in southern Alberta were positive for *Pasteurella tularensis* McCoy and Chapin, the causative organism of tularaemia.

The known range of the spotted fever tick extends from the Montana border on the south to Township 33 on the north, and from the Saskatchewan boundary on the east to the British Columbia boundary on the west. The area of greatest abundance is the semiarid rangeland region lying south of the Canadian Pacific Railway from Walsh to the Crow's Nest Pass. Within this region the density of the tick population varied with the district but the highest population was found along the river valleys and in the coulees.

It was observed that ticks were more plentiful in small coulees and draws that were well covered with vegetation and possessed numerous cattle paths. The majority of the ticks were usually found on the western and southern slopes of such coulees.

The importance of the spotted fever tick cannot be overrated for it is a known transmitter of Rocky Mountain spotted fever, tularaemia, and human and animal tick paralysis in this province. During the course of the survey a new disease of man, believed to be transmitted by this tick, was located in the Eastend district of Saskatchewan.

Nine other species of tick are known to be present in Alberta but they were not studied in detail. Two of these, the rabbit tick, *Haemaphysalis leporis-palustris* Packard, and the bird tick, *Haemaphysalis cinnabarina* Koch, are known disease vectors.

Introduction

The Alberta Rocky Mountain Spotted Fever Survey was organized in the spring of 1938 to investigate the possible presence of ticks and tick-borne diseases in southern Alberta. It was organized as a co-operative effort, being financed by the Alberta Department of Public Health and the International Health Unit of the Rockefeller Foundation, while the Laboratory of Hygiene of the Dominion Department of Pensions and National Health assumed the responsibility for all of the bacteriological work.

During the course of the survey particular attention was paid to the occurrence of the spotted fever tick and a detailed study of its life history, habits, ecological aspects, distribution, and importance was undertaken. On account of the lack of adequate laboratory space the life history study had to be abandoned, but all of the other investigations were carried out.

[1] *Manuscript received in original form August 16, 1943, and as revised, November 9, 1943. Contribution from the Department of Entomology, University of Alberta, Edmonton, Alta.*

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The Spotted Fever Tick

Historical

This tick was first described in 1905 by Stiles as *Dermacentor andersoni.* In 1908 it was again described by Banks (1) as *Dermacentor venustus*, and he stated that "This species is quite common in the Northwest . . . . .This is the species supposed to be concerned in the transmission of spotted fever in Montana".

The determination by Banks was accepted by all workers, and in the older literature the spotted fever tick is always referred to as *Dermacentor venustus* Banks. About 1925 it was discovered that Stiles' determination had priority, and in 1927 Stiles and Hassall (25) list the spotted fever tick as *Dermacentor andersoni* Stiles, and state that the name *venustus* must be considered dead.

The Rocky Mountain spotted fever tick was first reported from Alberta in 1915 when Hewitt (13) recorded that a specimen was collected at Pincher Creek in July of 1912. Hearle (11) in 1938 reported the tick as occurring in southern Alberta. Gibbons (8) in 1940 reported *Dermacentor andersoni* in southern Alberta as carrying both Rocky Mountain spotted fever and tularaemia infection.

Description

The spotted fever tick is a member of the family Ixodidae, and is characterized by having a chitinized shield on the dorsum, and the head projecting in front of the body. The males and females can be distinguished by the fact that the chitinized shield covers the greater part of the male's dorsum (Fig. 1), whereas in the female the shield is restricted to a small crescent-shaped area on the anterior part of the dorsum (Fig. 2). In both sexes the shield has greyish-white markings. The stigmal plate has a definite angulate prolongation.

The unfed adults are small, flat, brown, and very hard. They cannot be crushed. On engorgement, however, the female increases in size, the body becomes very large and soft, and assumes a putty colour and a waxy feel. The male, which feeds only slightly, never becomes engorged to the same extent as the female, and always retains the usual coloration and shape.

Life History

The life history of the spotted fever tick is very complicated, with four definite stages, egg, larvae (seed), nymph, and adult, and a life cycle of two or more years. It is a three-host tick with each active stage, on engorgement, dropping to the ground and moulting, and then transferring to another host-animal.

In Alberta, the adult, which Brown (3) found to be abundant from April to August (the peak of abundance being reached during May) feeds in nature on such wild animals as coyotes, rabbits, antelopes, deer, and mountain goats, and on such domestic animals as horses, cattle, and sheep. It feeds by in-

serting the mouth parts into the animal and drawing up blood, the female gradually increasing in size until it attains the size and shape of a bean, the male increasing very little in size. It takes about 12 days for the female to become completely engorged.

Copulation takes place on the host-animal, and copulating ticks have been recovered from horses and range sheep in southern Alberta. Cooley (5) states that often one male will fertilize two or three females.

The female is fertilized during engorgement and as soon as engorgement is completed she drops to the ground and seeks a favourable place for egg-laying. This is usually under stones or around the crown of a grass plant, and here she lays, according to Cooley (5), between 2000 and 8000 eggs usually in batches of 250. When the eggs are laid the female dies. The length of time required for egg-hatching depends on the temperature and varies between 17 and 51 days.

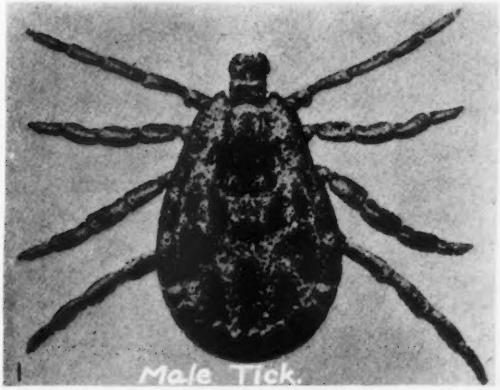
The eggs hatch into very small, six-legged creatures that are known as 'seed' ticks or larvae. These seed ticks crawl up on vegetation and wait for some small rodent, such as a field mouse or ground squirrel, to pass within reach, and as the rodent brushes past they transfer to it. They work their way through the fur to the skin where they insert their mouth parts and feed for three to eight days. When engorged they fall to the ground and after a period of time moult into nymph ticks. These are of medium size and possess four pairs of legs.

The nymphs usually go into hibernation during the fall and winter, and come up in the spring hungry and looking for a host. They crawl up on vegetation and await the passing of some small animal such as a field mouse, ground squirrel, or rabbit. When the animal brushes past they transfer to it and work through the fur to the skin—usually around the neck or in some place where the animal cannot dislodge them—and attach and start feeding. In about a week or 10 days the engorgement is completed and the nymphs drop to the ground and moult into adult ticks. These adults may find a host-animal, or they may remain in a quiescent state during the summer months, and then go into hibernation until the following spring. If they transfer to a host-animal then they will have completed the normal two-year cycle.

In the early spring, as soon as the snow melts, the adult ticks crawl up on vegetation and await the passing of a suitable host, but they now limit their choice to those animals from the size of a rabbit up and will readily attach to man.

As both nymphs and adults will overwinter there are always two stages present in the spring, one a year behind the other in its life cycle. Both nymphs and adult ticks have been collected from the same rabbit in Alberta.

According to Cooley (5) the adults can, in the absence of suitable hosts, live for four years without feeding. That is, at the approach of hot, dry weather the adult ticks that have not had an opportunity to feed will go down to the ground and remain in seclusion until the following spring when they



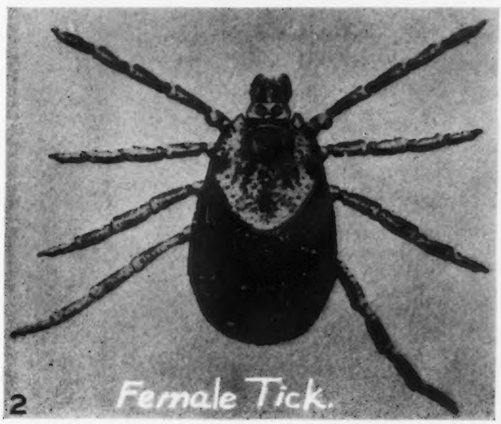


FIG. 1. *Dermacentor andersoni; male. After Cooley.*
FIG. 2. *Dermacentor andersoni; female. After Cooley.*

again crawl up on vegetation and await a host. Failing to find a host they will repeat the period of waiting and come up the following spring. In some cases they have been known to repeat again the period of waiting and to come up for the fourth year.

This ability to survive for such long periods of time without feeding, coupled with the enormous number of eggs that are laid, is thought to be nature's way of ensuring that this tick, which is so dependent on a succession of hosts, will have an opportunity to maintain its existence.

Habits

The adult spotted fever tick prefers animal hosts but it will readily attach to man, transferring from vegetation to the clothing. Being negatively geotropistic it crawls upward, working its way amongst the clothing to the skin where it inserts its mouth parts and feeds by drawing blood.

The adult tick in waiting for a host hangs on vegetation with the head downward. It hangs on with all four pairs of legs until it senses the approach of a potential host-animal; then it releases and waves in the air all of the legs except the third pair, ready to transfer to the host. This phenomenon was first witnessed in Alberta in 1938 while ticks were being collected in the Chin Coulee. In 1942 it was again observed in the Verdigris Coulee. In both coulees the ticks were clustered on sparse vegetation growing on erosion clay at the base of cutbanks, and considerable time was spent in studying the method of transference to host-animals.

Tick Infested Areas in Alberta

Investigations carried on since 1938 have disclosed that spotted fever ticks are very abundant in southern Alberta, and that their known range (Fig. 3) extends from the Montana border north to Township 33, and from the Saskatchewan border on the east to the British Columbia border on the west. The area of greatest abundance is that part of southern Alberta (Fig. 3) that is bounded as follows:— on the south by the Montana border; on the east by the Saskatchewan border; on the north by the Canadian Pacific Railway line from Walsh to the Crow's Nest Pass; and on the west by the British Columbia border.

Prior to 1938 sporadic reports of ticks were received, and these were mostly from the extreme southeast part of the province. Since the initiation of the Rocky Mountain Spotted Fever Survey in 1938 a total of 58,534 drag ticks and 3851 host ticks have been collected. These ticks were taken in 412 separate collections and, of these, two collections were positive for Rocky Mountain spotted fever infection while 16 were positive for tularaemia infection.

The following table (Table I) records the tick collections by districts and years for the period 1938 to 1942.

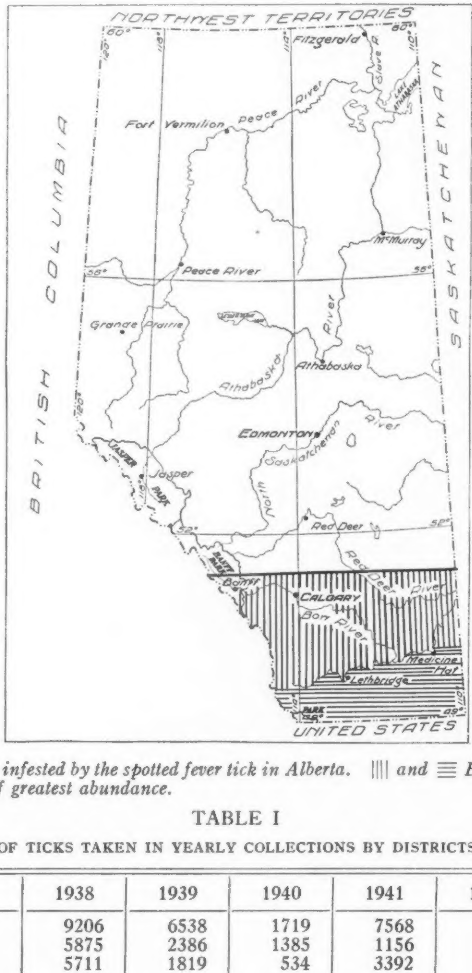


FIG. 3. *Areas infested by the spotted fever tick in Alberta.* |||| *and* ≡ *Extent of known tick area.* ≡ *Area of greatest abundance.*

TABLE I

NUMBER OF TICKS TAKEN IN YEARLY COLLECTIONS BY DISTRICTS, 1938–42

Districts	1938	1939	1940	1941	1942	Total
Manyberries	9206	6538	1719	7568	804	25835
Foremost	5875	2386	1385	1156	65	10867
Milk River	5711	1819	534	3392	241	11697
Cardston	10	—	—	—	—	10
Waterton	—	130	—	—	—	130
Medicine Hat	—	815	551	1801	1789	4956
Bow Island	39	—	—	444	1349	1832
Lethbridge	47	137	830	—	36	1050
Macleod	—	—	—	5	—	5
Hilda	—	—	—	19	—	19
Brooks	—	142	2914	558	1293	4907
Bassano	—	30	—	—	62	92
Empress	—	—	—	22	—	22
Cessford	—	—	—	97	261	358
Hussar	—	—	—	6	23	29
Consort	—	—	—	6	—	6
Hanna-Youngstown	—	335	195	38	—	568
Drumheller	—	—	2	—	—	2
Total	20,888	12,332	8130	15,112	5923	62,385

In order to convey a clear picture of the tick situation in southern Alberta the following table (Table II) has been arranged. This table records by years for each district the number of collections made, the number of host and drag ticks taken, and the number of collections found to be harbouring tularaemia or spotted fever infected ticks.

TABLE II

NUMBER OF COLLECTIONS MADE, NUMBER OF DRAG AND HOST TICKS TAKEN, AND NUMBER OF POSITIVES FOUND DURING THE FIVE YEAR PERIOD OF 1938 TO 1942, DY DISTRICTS

District	Year	No. of coll.	Ticks		Pos. collections	
			Drag	Host	Tul.	S.F.
Manyberries	1938	25	9124	82	4	—
	1939	18	6463	75	1	1
	1940	19	1628	91	—	—
	1941	29	6738	830	2	—
	1942	9	778	26	—	—
Total		100	24,731	1104	7	1
Foremost	1938	15	5753	122	—	—
	1939	6	2382	4	—	—
	1940	8	1350	35	—	—
	1941	5	1152	4	—	—
	1942	3	39	26	—	—
Total		37	10,676	191	—	—
Milk River	1938	13	5566	145	3	—
	1939	8	1771	48	—	—
	1940	7	510	24	—	—
	1941	17	3369	23	—	—
	1942	3	241	—	—	—
Total		48	11,457	240	3	—
Cardston	1938	1	10	—	—	—
Waterton	1939	21	59	71	—	—
Medicine Hat	1939	9	600	215	—	—
	1940	8	524	27	1	—
	1941	14	1780	21	—	—
	1942	28	1757	32	1	—
Total		59	4661	295	2	—
Bow Island	1938	1	39	—	—	—
	1939	—	—	—	—	—
	1940	—	—	—	—	—
	1941	6	101	343	1	—
	1942	18	1296	53	4*	—
Total		25	1436	396	5	—
Lethbridge	1938	1	47	—	—	—
	1939	4	100	37	—	1
	1940	5	830	—	—	—
	1941	—	—	—	—	—
	1942	1	36	—	—	—
Total		11	1013	37	—	1

* *Of the four positives for tularaemia one was a tissue specimen taken from a jack rabbit found dead.*

TABLE II—*Concluded*

NUMBER OF COLLECTIONS MADE, NUMBER OF DRAG AND HOST TICKS TAKEN, AND NUMBER OF POSITIVES FOUND DURING THE FIVE YEAR PERIOD OF 1938 TO 1942, BY DISTRICTS—*Concluded*

District	Year	No. of coll.	Ticks		Pos. collections	
			Drag	Host	Tul.	S.F.
Macleod	1941	1	5	—	—	—
Hilda	1941	3	3	16	—	—
Brooks	1939	4	128	14	—	—
	1940	15	2752	162	—	—
	1941	16	122	436	—	—
	1942	12	1206	87	—	—
Total		47	4208	699	—	—
Bassano	1939	1	30	—	—	—
	1942	6	16	46	—	—
Total		7	46	46	—	—
Empress	1941	3	—	22	—	—
Cessford	1941	6	—	97	—	—
	1942	3	229	32	—	—
Total		9	229	129	—	—
Hussar	1941	1	—	6	—	—
	1942	4	—	23	—	—
Total		5	—	29	—	—
Consort	1941	1	—	6	—	—
Hanna-Youngstown	1939	6	—	335	—	—
	1940	22	—	195	—	—
	1941	5	—	38	—	—
	1942	—	—	—	—	—
Total		33	—	568	—	—
Drumheller	1940	1	—	2	—	—

The following table (Table III) records by districts the number of years each area was surveyed, the number of collections made, the number of drag and host ticks taken, and the number of tularaemia and spotted fever positives found.

During the course of the five-year investigation it soon became apparent that although the density of tick population varied from district to district there was a very definite correlation of tick numbers with the type of locality. This matter was investigated quite thoroughly and it was found that it was possible to map the areas of tick population (Fig. 4).

TABLE III

District	No. of Years	No. of Coll.	Ticks		Pos. Collections	
			Drag	Host	Tul.	S.F.
Manyberries	5	100	24,731	1104	7	1
Foremost	5	37	10,676	191	—	—
Milk River	5	48	11,457	240	3	—
Cardston	1	1	10	—	—	—
Waterton	1	21	59	71	—	—
Medicine Hat	4	59	4661	295	2	—
Bow Island	3	25	1436	396	5*	—
Lethbridge	4	11	1013	37	—	1
Macleod	1	1	5	—	—	—
Hilda	1	3	3	16	—	—
Brooks	4	47	4208	699	—	—
Bassano	2	7	46	46	—	—
Empress	1	3	—	22	—	—
Cessford	2	9	229	129	—	—
Hussar	2	5	—	29	—	—
Consort	1	1	—	6	—	—
Hanna-Youngstown	3	33	—	568	—	—
Drumheller	1	1	—	2	—	—
Total		412	58,534	3851	17*	2

* *One collection was tissue from a jack rabbit found dead.*

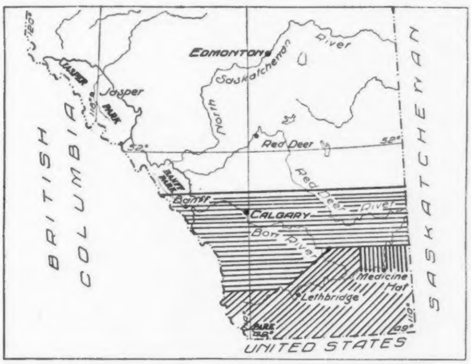


FIG. 4. *Areas of the spotted fever tick population in southern Alberta.* ≡ *Light infestation.* //// *Heavy infestation.* |||| *Medium infestation.*

A study of the map will show that the districts having the greatest density are in the extreme southeast part of the province, and along the Bow, Old Man, and South Saskatchewan rivers; and it will be observed that these same areas are the rangelands that support large numbers of sheep and cattle.

The areas of medium density contain those districts in which much land is under cultivation, although large herds of cattle and flocks of sheep are also ranged.

The areas of light intensity are those districts in which grain farming is the main endeavour.

This distribution of tick population is as would be expected because on the rangeland there would be sufficient hosts for all stages of the life cycle, while in the mixed farming areas the smaller number of cattle and sheep, and the intensive ground-squirrel control work, would reduce the number of hosts. In grain farming areas the number of hosts for all stages of the life-cycle would be at a minimum.

Activity

It is usually taken for granted that ticks are active only during the daylight hours. Very little information can be found in the literature regarding the diurnal activity and none at all regarding nocturnal activity. During 1938 an attempt was made to find out if there was any nocturnal activity and the results obtained, although insufficient for drawing any definite conclusions, indicate that ticks are active at night. These conclusions were based on a comparison of a series of collections made during the mornings, afternoons, and evenings of consecutive days.

In theory, ticks should be just as active during the night as during the day, probably more so, for it is at night that the native host-animals are the most active, and if ticks became inactive during the hours of darkness their chances of transferring to a host-animal would be very slight. There is also another factor that must be evaluated when considering the probability of nocturnal activity, and that is the effect of temperature. Cooley (5) records that ticks become inactive at the onset of hot, dry weather, which implies that they are more active at low temperatures. It is well known that there is a considerable drop in temperature at the beginning of night in Alberta, and this condition might well produce increased activity on the part of the ticks.

An important point in relation to the effect of temperature on activity has been observed in Alberta during the last five years of tick investigational work, and this point is that during very hot or very cold weather ticks do not readily transfer from the vegetation to the tick-drag, instead they appear to draw in their legs and drop to the ground when the cloth drag is pulled over the vegetation. It has been also observed that those ticks that do transfer to the drag will immediately draw in their legs and remain inactive.

Another point that aroused considerable interest was the effect, if any, of snow and rain on tick activity. Very little information is available on this subject so an attempt was made to answer the problem. The answer was sought by carrying out dragging operations during both rain and snow storms but, owing to the fact that the tick-drag became saturated, and thereby useless, when dragged over the wet vegetation, no definite conclusions could be reached. It was shown, however, that ticks could be taken during both rain and snow storms as long as the tick-drag remained dry. From this it would appear that ticks do not seek shelter during storms.

Ecology

Ticks have been collected in a great variety of surroundings in Alberta, ranging from the sage-brush– and rose-bush–filled coulees of the southeastern part of the province to the timbered slopes of the Rocky Mountains, but, in general, typical Albertan tick country can be spotted at a glance. It is usually a small coulee or draw, well covered with vegetation and possessing numerous cattle paths. It invariably has an eastern or northeastern exposure, and the majority of ticks are usually found on the western and southern slopes. This is particularly noticeable in the Verdigris Coulee, an old river-bed east of the town of Milk River. Here ticks are exceedingly plentiful in the small draws on the west bank while similar draws on the east bank are devoid of them.

The choice of situation of adult ticks varies with different districts. In the sage-brush country of southeastern Alberta the best collecting areas are cattle paths through brush-filled coulees, for these paths are used not only by cattle but also by the native animals so that there is always a constant supply of host-animals for all active stages of the tick's life cycle. Only on one occasion have ticks been collected on the prairie proper, and these were taken on a small area in a sheep pasture.

In the Manyberries district where a very large number of ticks have been collected (see Table I), there are two main types of tick locality. The first type is found in the North Branch of the Manyberries Creek which is a shallow, wide coulee with alternating patches of grass and brush. A small stream winds through the coulee and it is criss-crossed with paths made by animals seeking water. Small wild animal life is plentiful. This area is of extreme importance because spotted fever infected ticks have been collected here, and five* human cases of Rocky Mountain spotted fever, four of which were fatal, have occurred on the west bank of this creek. The second type occurs about seven miles southeast of Manyberries and consists of a long, narrow, and deep coulee, which is badly eroded on the bottom. There is considerable brush, but the cattle paths avoid it and are located about midway up the sides of the coulee. In this area the best dragging was on the grass along the paths, and it was here that the Albertan record was set when 2100 ticks were collected by two men in six hours of dragging. A single drag of the cloth would often yield as high as 15 ticks.

On the south branch of the Manyberries Creek ticks are very scarce although the same type of vegetation is present.

In the Milk River district, where the next largest number of ticks have been collected (Table I), ticks are most abundant on small patches of short, green grass on the west slope of the Verdigris Coulee. During 1942, ticks were also collected from sparse vegetation growing on the erosion clay at the base of cutbanks on the west slope of the coulee. These ticks were present in large

* *One of the cases not definitely proven to be Rocky Mountain spotted fever.*

numbers and were very active, and considerable time was spent in studying their method of transference to host-animals.

At Foremost where the third largest number of ticks have been collected, many ticks were taken on the vegetation that grows on the grey clay along the bottom of the south bank of the Chin Coulee. These ticks were first noticed in 1938, and during 1938 and 1939 much time was spent in studying their habitat and method of transference to host-animals.

In the Bow Island district, particularly the Seven Persons Coulee, ticks were collected from the vegetation that covers the bottom of the Coulee. In this area ticks are taken as readily from the sage-brush and rose-bush scattered throughout the coulee as they are along the cattle paths.

In the Brooks district all of the ticks are located on the rangeland surrounding Lake Newell, and along the Bow River.

Ticks are very plentiful in the Medicine Hat district and have been collected on the golf course, and in small coulees in the residential section of the city. At Walsh, a small town east of Medicine Hat, the greatest number of ticks ever taken on a single drag in Alberta were collected in 1939; here a "drag", made on the short grass where a coyote path crossed a small draw, yielded 32 drag ticks.

In the Lethbridge district ticks have been taken on the east bank of the Old Man River within a few blocks of the centre of the city. One collection made on the river bank about five miles from the city in 1939 was found to contain spotted-fever–infected ticks.

It can be said that in southern Alberta ticks will be found throughout the rangeland area generally, and especially in districts where the distribution of host-animals is such that the completion of the life cycle is assured. It can further be said that there are definite indications that ticks are becoming more common in old areas of infestation and that they are becoming established in new areas.

Probable Cause of Tick Abundance in Southeastern Alberta

There has recently been much speculation regarding the abundance of ticks in southeastern Alberta, and many persons are of the opinion that the tick population has increased greatly in the past few years while others are of the opinion that ticks have just lately moved into the country.

In an attempt to settle this problem interviews were held with many of the early settlers and as much information as possible was gathered. The consensus of opinion amongst the early ranchers was that ticks were well-established when they arrived but that there has been a very decided increase in tick population since 1900. The cause for this increase was not definitely known but it was suggested that the suppression of prairie fires, which usually occurred in May—the period when ticks were most active—would reduce the tick mortality from this cause, and the introduction of large flocks of sheep

would increase the number of host-animals for the adult ticks, thereby giving them more opportunities to feed, mate, and reproduce.

The introduction of all types of domestic animals which follows the settling of a new district would also increase the numbers of host-animals available to the adult ticks.

Importance

The spotted fever tick is of great importance for it is a known transmitter of Rocky Mountain spotted fever and tularaemia, two very serious human diseases; and it is also the cause of tick paralysis in man, cattle, and sheep.

This tick first assumed importance in 1903 when Wilson and Chowning (30) advanced the theory that spotted fever was a tick-borne disease. This theory was proven in 1906 when Ricketts (24) succeeded in transmitting the disease from an infected to a healthy guinea pig by means of a female tick. Later in the same year he showed that the male tick could also transmit the disease. At the same time King (14), who was experimenting with the possibility of tick transmission of the disease, was able to confirm Ricketts' work. In 1911 Maver (17) reported on the transmission of spotted fever in nature by this tick. In 1917 Parker and Wells (23) recorded some important facts concerning the spotted fever tick, and since that time Parker has devoted his energies to a detailed study of this tick in relation to disease. In 1939 Gibbons (7) reported ticks of this species infected with the spotted fever organism as being present at Lethbridge and Manyberries in Alberta.

The first record of this tick being infected with tularaemia was made in 1924 by Parker, Spencer, and Francis (22) when *Pasteurella tularensis* McCoy and Chapin, the causative organism, was recovered from ticks collected in the Bitter Root Valley, Montana. Since that time it has been demonstrated that a very high percentage of ticks carry this infection. In 1939 Gibbons (7) reported ticks collected in southern Alberta as being infected, and in 1941 he made a further report of infected ticks being present.

Since 1938 a total of 16 collections of drag and host ticks taken in different areas in the extreme southern part of the province have been demonstrated to be carrying *Pasteurella tularensis*. In the same time three proven and five suspected cases of tularaemia in man have occurred in the same general area.

Tick paralysis in man was first noted by Todd (28) in 1912 when he recorded the effect of tick bites on man in British Columbia. McCornack (15), working in the state of Washington in 1921, substantiated Todd's work. Hadwen (10) in 1913 reported on the occurrence of human tick paralysis. Mail and Gregson (16) in 1938 reported on the occurrence of tick paralysis in British Columbia. One definite and two suspected cases of tick paralysis in man have occurred in Alberta since 1938.

Tick paralysis in sheep was recorded in 1913 by Hadwen (10) when he published his findings on the effect of tick bites on sheep. Nuttall (19) in 1914 recorded further work. Hearle (11) in 1938 recorded the occurrence

of tick paralysis in British Columbia. Two cases of tick paralysis in sheep have occurred in Alberta since 1938.

Tick paralysis of cattle in Canada appears to be confined to British Columbia. Moilliet (18) in 1937 reported on the occurrence of this disease. Hearle (11) in 1938 published further information. No cases of tick paralysis in cattle have been located in Alberta to date.

Besides the spotted fever tick, *D. andersoni*, nine other species of tick have been reported from Alberta. They are as follows:

The moose tick	*Dermacentor albipictus* Packard
The rabbit tick	*Haemaphysalis leporis-palustris* Packard
The bird tick	*Haemaphysalis cinnabarina* Koch
The spinose ear tick	*Ornithodoros megnini* Dugès
	Otobius lagophilus Cooley & Kohls
	Ixodes kingi Bishopp
	Ixodes pratti Banks
	Ixodes marmoti
	Ixodes sculptus Neumann

The Moose Tick

The moose tick, *Dermacentor albipictus*, is confined mostly to the mountainous and northern parts of the province. It, as its name indicates, infests moose and other ungulates such as deer and elk.

The moose tick has not been recorded as a transmitter of disease to man, although it is a known vector for a bacterial disease in moose. It sometimes attacks horses and cattle causing considerable trouble through very severe infestations. Cameron and Fulton (4) working in Saskatchewan in 1927 reported an outbreak of this tick on cattle and horses. Thomas and Cahn (27), working in Illinois in 1932 reported a new moose disease transmitted by this tick. Wallace, Thomas, and Cahn (29) continued the work and made a further report in the latter part of 1932. Fenstermacher (6) working in Minnesota in 1933 and 1934 reported on tick-transmitted diseases in moose. Strickland (26) reports an infestation in moose at Elk Island Park, Alta., in 1939.

The moose tick is very active during the winter and early spring and, according to Hearle (12), heavy infestations of moose and other animals occur at this time.

The Rabbit Tick

The rabbit tick, *Haemaphysalis leporis-palustris*, is fairly common on jack rabbit species in Alberta. It is not confined to this animal for Strickland (26) reports that specimens were taken from turkeys at Lavoy, Alta., in August, 1927.

In 1924, Parker, Spencer, and Francis (22) reported the rabbit tick as a carrier of tularaemia in nature. Parker and Spencer (21) in 1926 reported the rabbit tick as the main vector of tularaemia in nature. Hearle (12) in

1938 stated that the periodic dying out of jack rabbits was in all probability due to tularaemia infection transmitted by this tick.

The Bird Tick

The bird tick, *Haemaphysalis cinnabarina*, has been taken on only one occasion in southern Alberta, and this was during 1942.

Parker, Philip, Davis, and Cooley (20) in 1937 reported that this tick was a probable transmitter of tularaemia to birds in nature. Hearle (12) in 1938 reported that this tick was extremely abundant on grouse in British Columbia.

The Spinose Ear Tick

The spinose ear tick, *Ornithodoros megnini*, has been taken in southern Alberta but it is not common.

Hewitt (13) records that this tick was taken from jack rabbits at Lethbridge in October, 1912, by Dr. A. Watson. Strickland (26) reports specimens being taken from a bush rabbit at Lethbridge in December 1931.

Otobius lagophilus

In December, 1941, Mr. H. L. Seamans, Entomologist-in-Charge, Dominion Entomological Laboratory, Lethbridge, Alta., collected a live tick from a cat in that locality. He sent the tick to Prof. R. A. Cooley, Rocky Mountain Laboratory, Hamilton, Montana, for identification. Prof. Cooley replied as follows: "I find the tick to be *Otobius lagophilus* Cooley and Kohls. This is the species which for years was confused with *Ornithodoros megnini* but which we found to be quite a different tick. Your specimen is of particular interest because it is the first known record of this tick on anything but rabbits".*

Ixodes kingi

Hearle (12) reports this tick as being taken from ground squirrel burrows in the Medicine Hat district. It is not a known disease transmitter.

Ixodes pratti

Hewitt (13) records this tick as being taken from dogs and cats at Milk River in July, 1911. Hearle (12) believes that the tick taken was really *I. kingi.*

Ixodes marmoti

The survey made a collection of this tick from Richardson ground squirrels during 1940. The determination made by Mr. J. D. Gregson, Dominion Entomological Laboratory, Kamloops, B.C., stated that the specimens might be *I. kingi.*

This tick is not a known disease vector.

Ixodes sculptus

This tick was collected from Richardson ground squirrels at Medicine Hat during 1942. The determination was made by Mr. J. D. Gregson, Kamloops, B.C.

* *The above information is recorded through the kind permission of Mr. H. L. Seamans.*

Discussion

The dog tick, *Dermacentor variabilis*, has not become established in Alberta as yet. Only one specimen has been taken here and it was removed from the neck of a lady tourist at Banff in June, 1939. Strickland (26) reports that the lady had lately arrived from Winnipeg, and as *D. variabilis* is common in that district, she may have picked up the tick before leaving Manitoba. The lady was not ill.

Green (9) reported on the transmission of tularaemia by this tick in 1931. Bishopp and Smith (2) give a very full description of its life history, habits, and importance.

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